

## KITE and MAM Technology Milestones (last technology gates for phase B)

M. Shao

Dec 2 ,2002

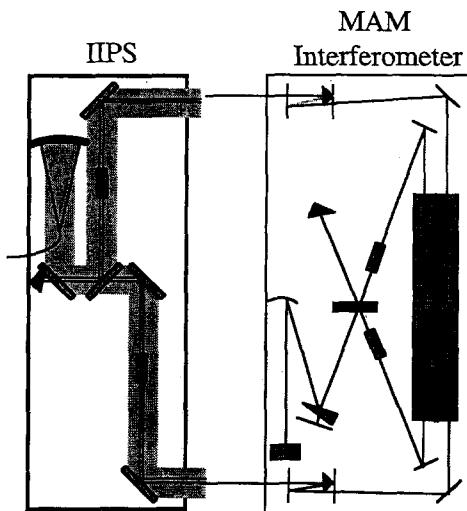
KITE & MAM Milestones

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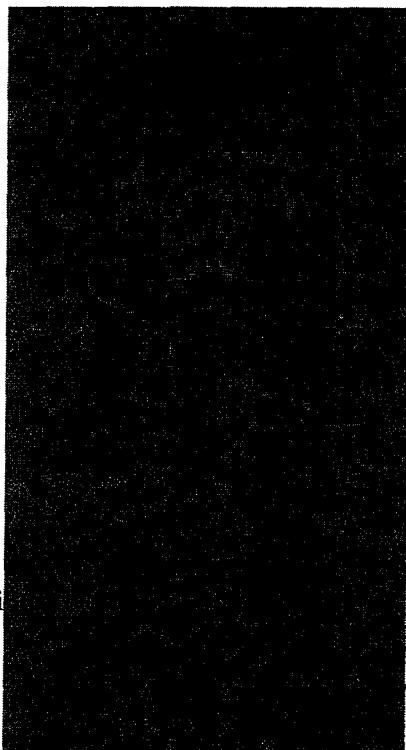
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- KITE and MAM milestones, their relation to SIM
  - System level demonstration of the basic 3uas narrow angle requirement
- Common concepts
  - SIM error budget, adopted to MAM and KITE
  - Field independent and Field dependent errors
  - SIM observation sequence, how data is analysed
- KITE milestone
  - Subsystems, Absolute Metrology,Metrology Pointing
  - Field dependent systematic errors
  - Experiment results
- MAM milestone
  - MAM Experiment description
  - Progression of experiments
  - MAM experiment results
- Summary

- Demonstration of SIM's fundamental measurement technique -- use of differential delay and stellar fringe position to measure relative star positions
- Inverse interferometer pseudostar (IIPS) articulates over MAM field of regard
  - MAM measures IIPS motion
  - IIPS internal metrology provides consistency test
- Technology Gate #4 -- Show the rms error meets the flight "basic requirement" for the narrow angle case:
  - 0.5 deg articulation



- Demonstration of external metrology truss in planar configuration
  - 4 fiducials (2 corner cubes + 2 triple corner cubes)
  - 6 metrology gauges connecting the 4 vertices
- Redundant truss allows a consistency experiment (5vs1)
- Account for CC imperfections using CC calibration and model
- Technology Gate #3 -- Show the rms error meets flight "basic requirement" for the various cases of:
  - 0.5 deg articulation (Narrow Angle)
  - 7.5 deg articulation (Wide Angle)
  - Simulated PSS thermal deformation





Narrow Angle  
Astrometric Accuracy  
1.07 uas

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Space Interferometry Mission

**SIM**

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>.007

Baseline  
Estimation Error  
18 uas

Narrow Angle  
Measurement Error  
0.97 uas  
47 pm

MAM  
Kite

Field Dependent  
Errors  
22 pm

Field Independent  
Errors  
28 pm

Brightness Dep  
Error  
30 pm

Stellar Aberration  
4 pm

Science Interf  
21 pm

Delay Line Cal  
17 pm

Sid/Corner Cube  
13 pm

External Met  
7 pm

Sid/Corner Cube  
4 pm

ACS/Control  
Induced Errors  
7 pm

Roll Error  
5 pm

Regularization  
Errors  
5 pm

External Met  
13 pm

Abs Met Error  
5 pm

Rel Ext Met Error  
7 pm

Interferometer  
Measurement Errors  
24 pm

Internal Met Error  
9 pm

WL FT Error  
7 pm

Optical  
Alignment  
8 pm

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Wide Angle  
Astrometric Accuracy  
3.2 uas

Baseline Length  
Error (10-20 hrs)  
1.1 uas

Single Tile  
Measurement Accuracy  
12.1 uas  
585 pm

Grid Multiplier

MAM  
Kite

Field Dependent  
Errors  
278 pm

FD Systematics  
1.5

Field Independent  
Errors  
266 pm

Brightness Dep  
Error  
437 pm

Stellar Aberration  
59 pm

Science Interf  
161 pm

Delay Line Cal  
106 pm

Sid/Corner Cube  
121 pm

External Met  
92 pm

Corner Cube Cal  
54 pm

ACS/Control  
Induced Errors  
82 pm

Roll Error  
20 pm

Regularization  
Errors  
80 pm

External Met  
130 pm

Interferometer  
Measurement Errors  
216 pm

Abs Met Error  
103 pm

Rel Ext Met Error  
43 pm

Internal Met Error  
43 pm

WL FT Error  
76 pm

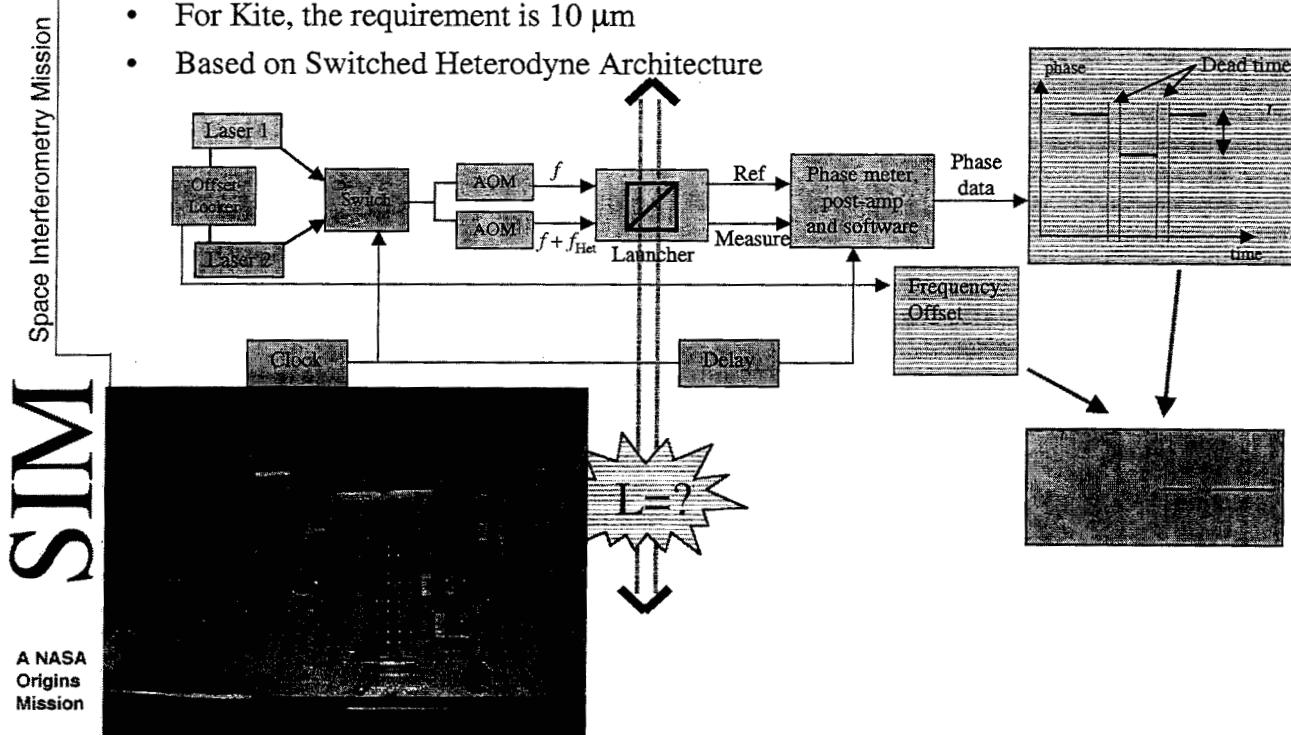
Error Btw IM and  
WL FT  
80 pm

KITE & MAM Milestones

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- SIM external metrology requires knowledge of absolute distances to  $3 \mu\text{m}$
- For Kite, the requirement is  $10 \mu\text{m}$
- Based on Switched Heterodyne Architecture

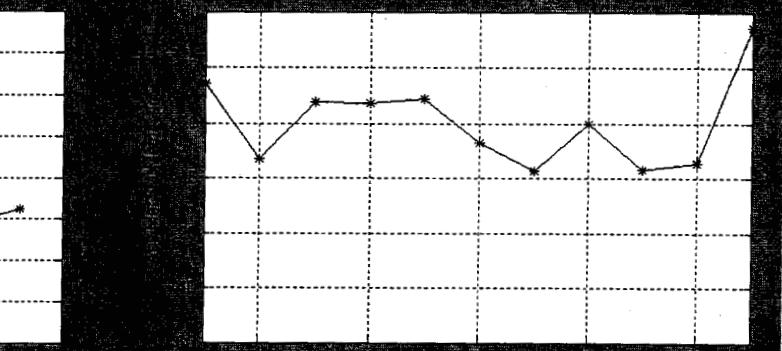
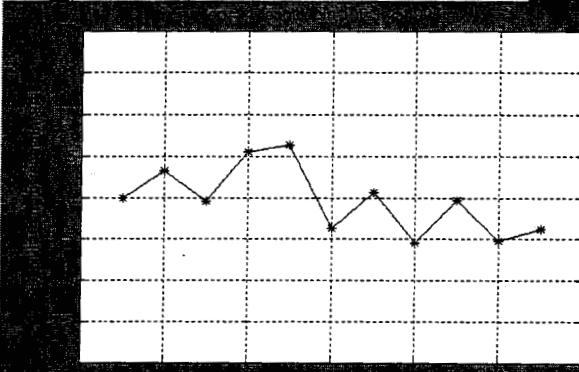
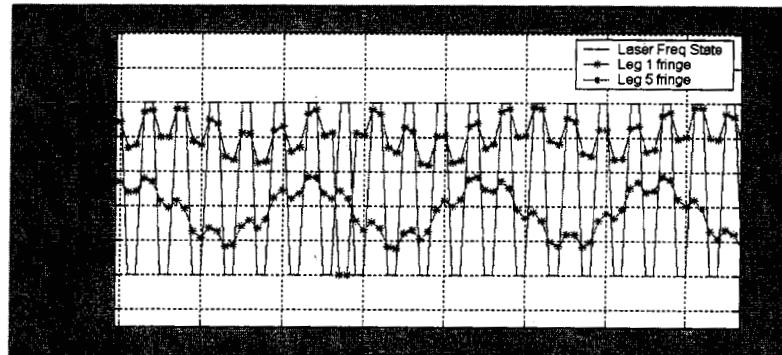


KITE &amp; MAM Milestones

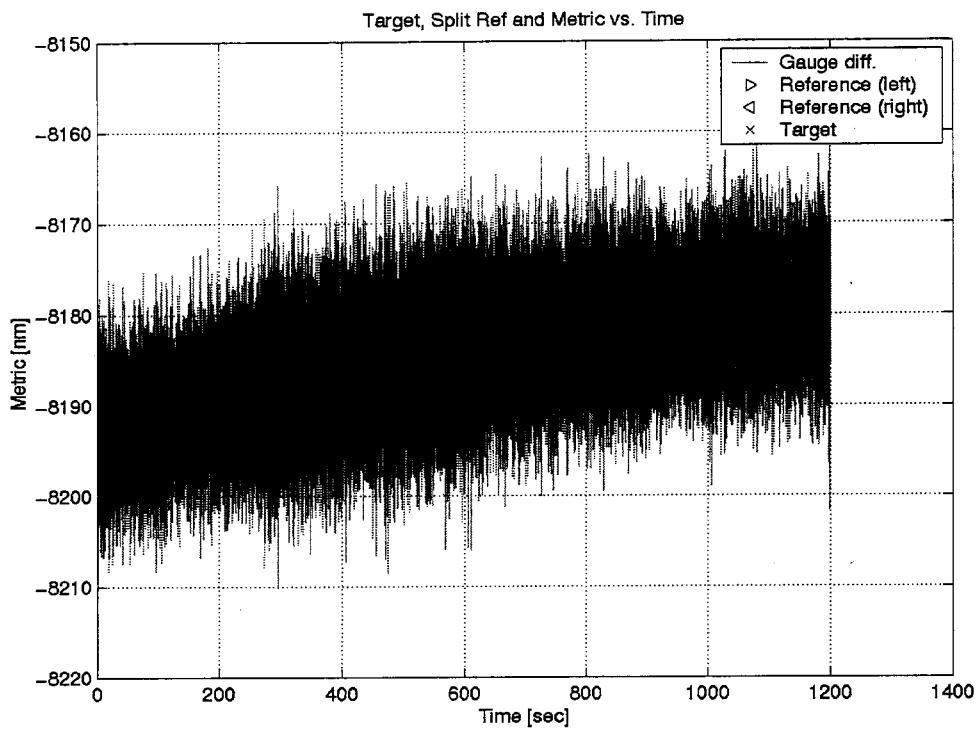
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- Space Interferometry Mission
- Switch lasers and measure phase change
- Account for phase wrapping
- Use redundancy as a diagnostic
  - “5-1 Metric”
- Typical performance:
  - $\sim 10 - 15 \mu\text{m rms} / \text{gauge}$



Space Interferometry Mission

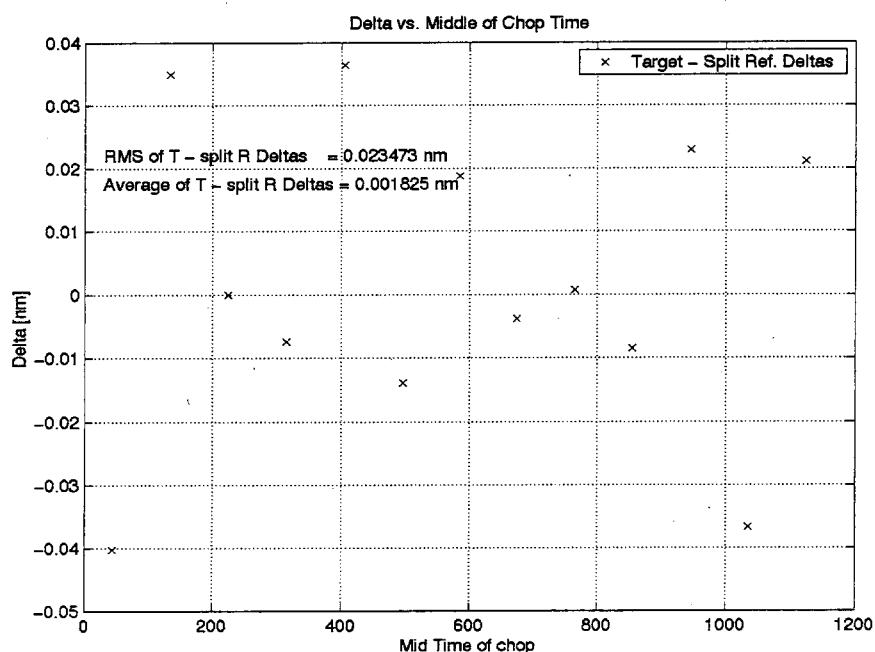
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Mission

KITE &amp; MAM Milestones

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- Projected NA FI error = 17 pm / gauge

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Perf. pm	<i>SIM</i> <i>Goal</i>	<i>SIM</i> <i>Requirement</i>	Kite '02 Milestone	Current Typical	Best Achieved
Wide Angle	111	835	300	247	101
Narrow Angle	12	49	50	27	14

KITE &amp; MAM Milestones

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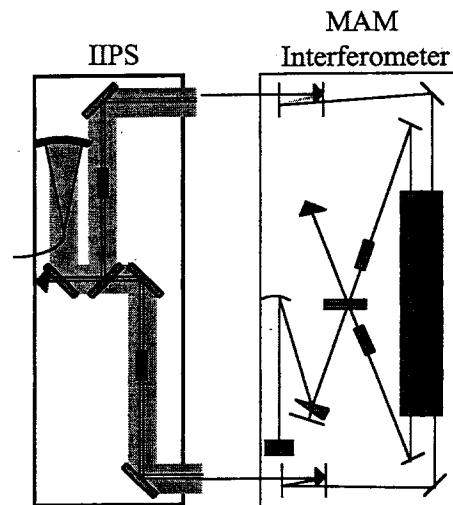
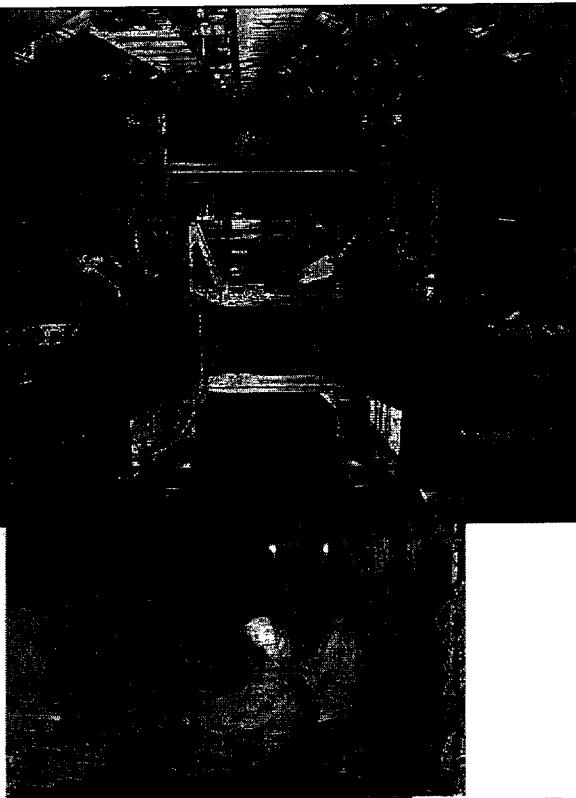
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NASA

## The MAM Experiment

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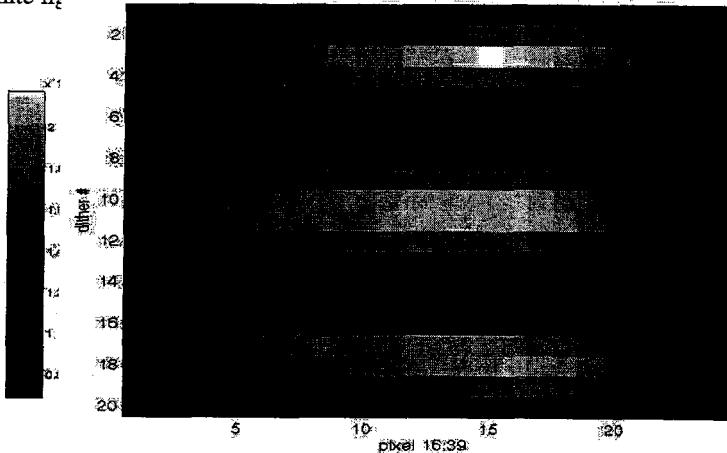
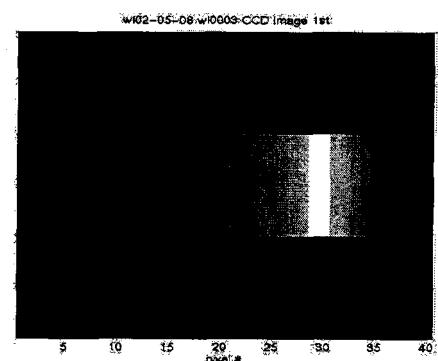
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# The Fringe Detection Process, Deviations from the ideal

- White light fringes are detected by modulating the optical path in a triangle wave pattern.
  - This basic technique is used in a wide variety of commercial interferometers.
- What sets SIM/MAM white light detection apart is the ability to modulate with a waveform that is known to picometer accuracy.
  - The measurement of the modulation waveform by internal metrology (at 1KHz) is used in the demodulation of the white light fringe.

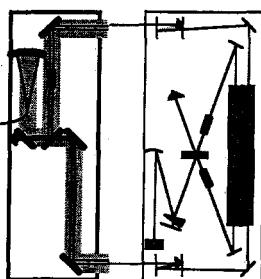


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## Quasi Static Test



## Nothing is intentionally moved

20~30nm vibration  
 100nm /1000 sec Optical path drift  
 3 urad/1000sec tip/tilt drift  
 10mK/hr thermal drift  
 Slow tilt (of vac chamber, 100's urad)

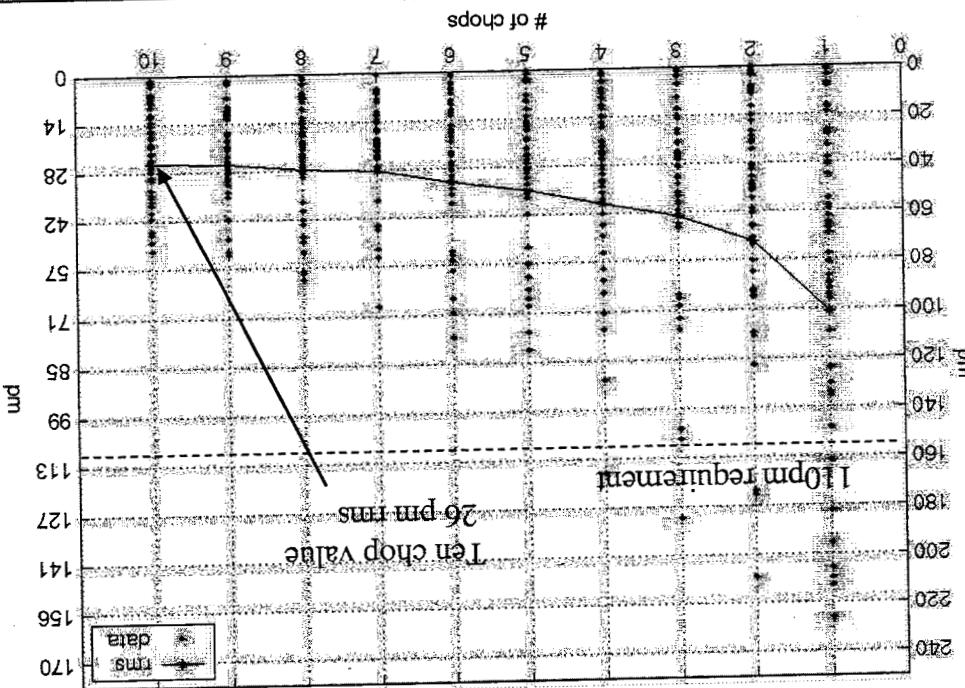
- New errors introduce because of a systems environment
  - Electrical noise (46Khz in SAF, Motor switching amp)
  - Electrical xtalk (initially -60db xtalk between SAVV channels)
  - Ground loops
    - Electrical non-linearities (120hz=> 100,120hz and 99,880hz)
  - Other(s)
- Thermal/mech stability of SAVV launcher mount
- Vibration much larger now than for W.L. test in Jan 02
  - Tank is a large acoustical antenna, table needs to be isolated from tank
- Alignment related drifts/errors/servo

TWS

Space Interferometry Mission

Raw TA + IIPS error

### Estimated TA only error



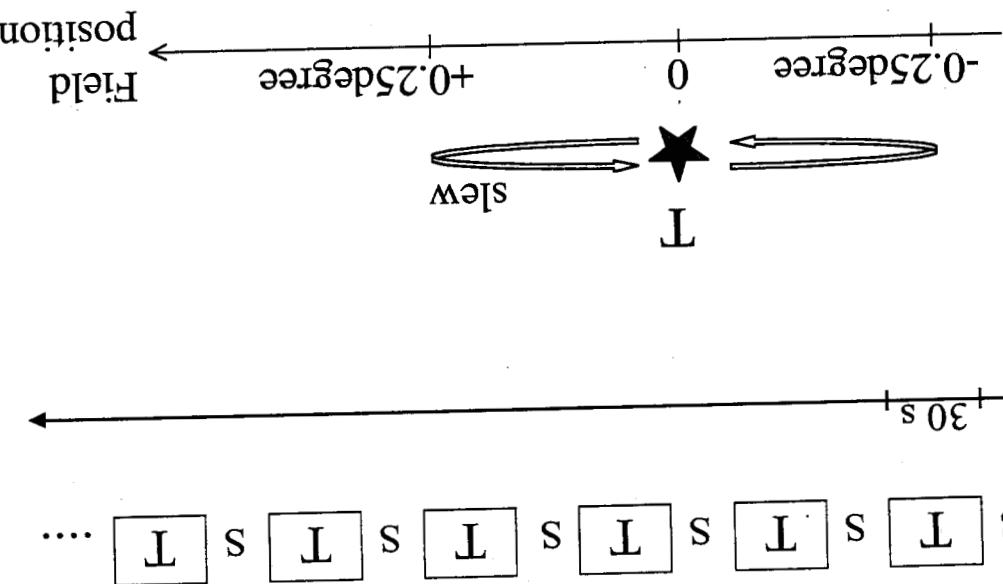
The "go and come back" test.

Error between white light and metrology paths as a function of the number of chops averaged together for



WJS

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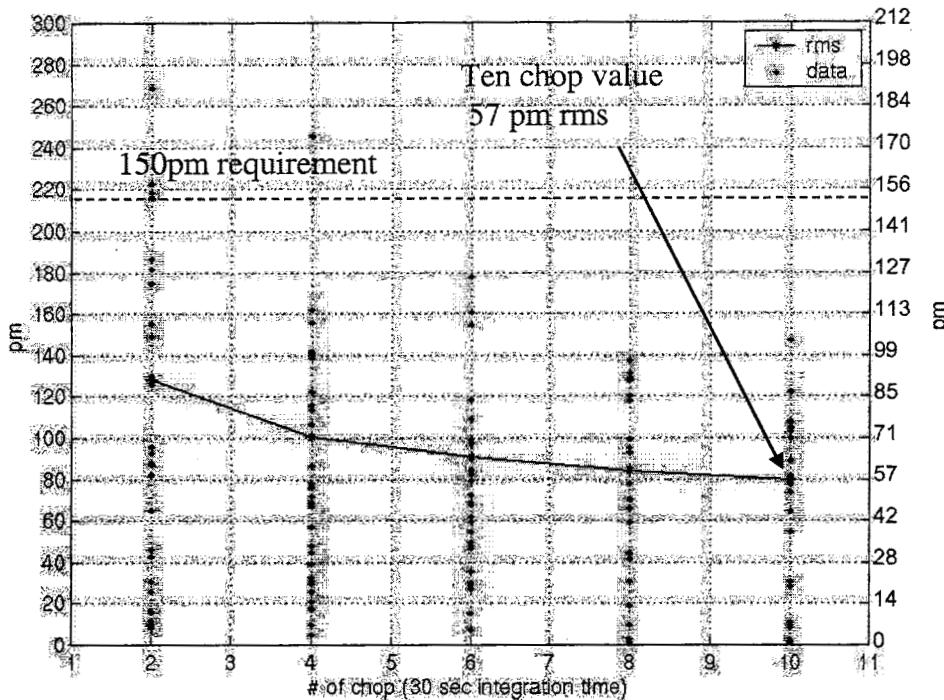


### Go and Come-back test



Error between white light and metrology paths as a function of the number of chops averaged together for the field dependent test.

Raw TA + IIPS error



Estimated TA only error

## MAM Results Summary

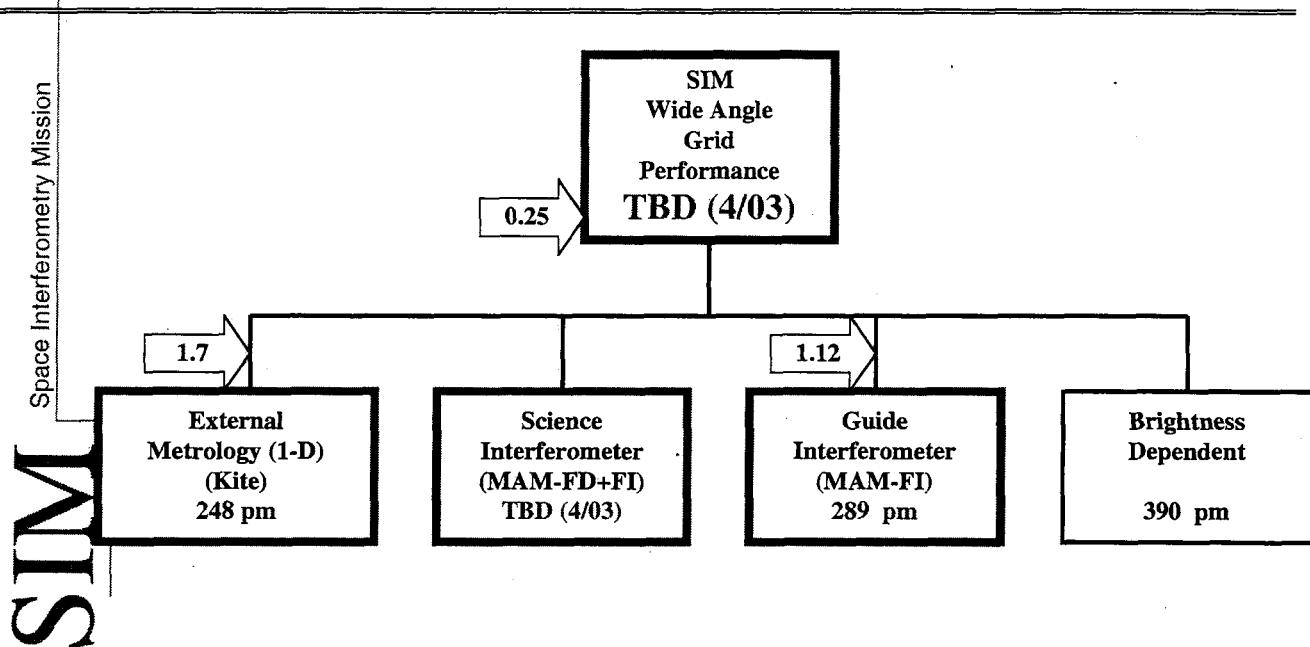
## NA Requirements (Differential)

MAM	Goal	Req			
Astrometry	1.1	3.0 uas			
FD	29.7	118.8 pm			
FI	21.8	87.1 pm			
All-in-one	36.8	147.3 pm			



## Current Wide Angle Performance

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## Summary

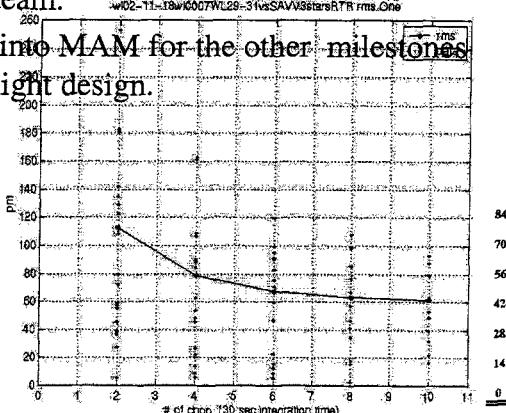
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Space Interferometry Mission

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- We understand picometers.
- Both the KITE and MAM milestones have been met (basic requirements) with considerable margin. (no if's or but's)
- Just a couple of months after passing the “basic” requirements, we are close to demonstrating that we can meet the Narrow Angle “goals” of the project (1uas narrow angle)
- In the process of meeting these milestones, we've built a very strong technology team, which is being integrated into the flight design team.
  - The lessons learned are being incorporated into MAM for the other milestones for entry into phase C, as well as the SIM flight design.
- We're ready to enter phase B.



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